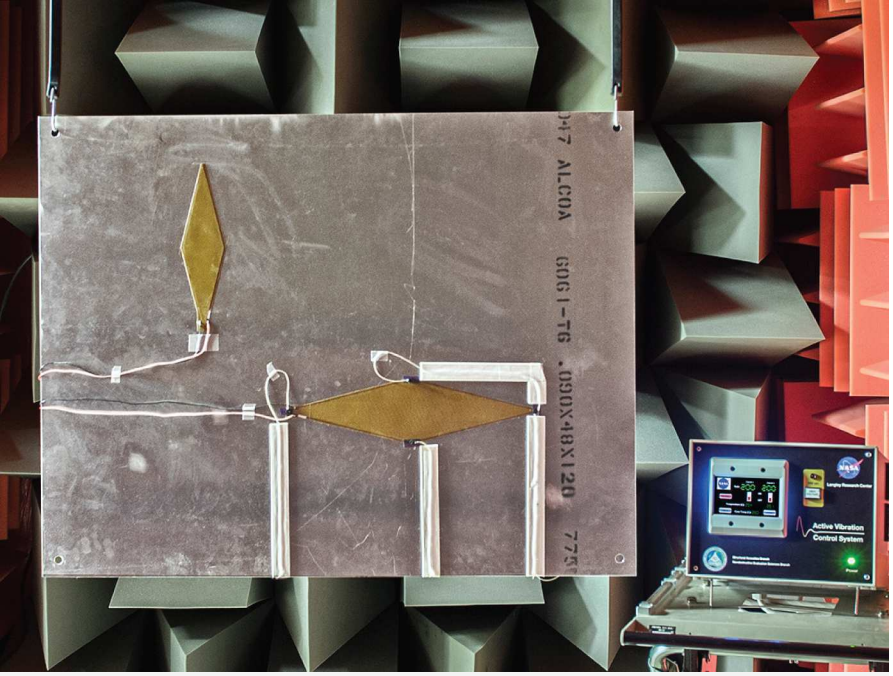


National Aeronautics and Space Administration

Aeronautics

Compact Active Vibration Control System

Active damping of flexible structures using a simple and compact actuator, sensor, and control system

NASA Langley Research Center has developed a point sensor and piezoelectric actuator system to actively sense and reduce vibrations in flexible structures.The system uses a directional piezoelectric actuator that couples to an underlying structure like four point forces acting normal to the structure. Four miniature accelerometers are located coincident with the piezoelectrics point forces to create a matched actuator/sensor pair. This matched pair enables feedback control to be implemented using simple, robust, negative feedback that requires no knowledge of the dynamics of the structure and can be implemented using analog electronics. When attached to a flexible structure, this active damping system can reduce vibrations in a variety of applications. Compared to other systems, this approach offers good performance with a simple and compact control system.

BENEFITS

- Compact, lightweight design:
  -- 6.4 38 cm long, 0.3 mm thick
  -- 0.16 g/cm2 density actuator
  --Compact analog control circuit
- Effective damping over a broad frequency range (several kilohertz
- Longer actuators enable lower frequency performance: 15 inch actuator effective to 50 Hz in aluminum, 70 Hz in thin steel
- Simple DC power requirements
- Non-model-based control; does not require detailed knowledge of structural dynamics

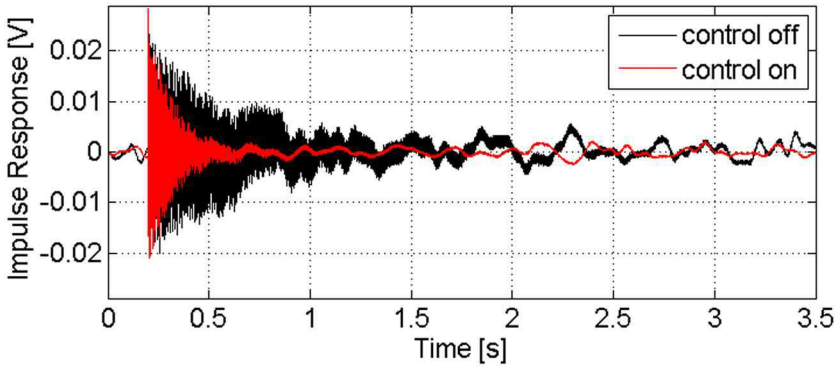
APPLICATIONS

- Aeronautics - reduce vibration and noise in helicopters or airplanes
- Aerospace - stabilize larger space structures
- Manufacturing - reduce noise radiation from vibrating panels
- Electronics - stabilize optical components or other sensitive machinery

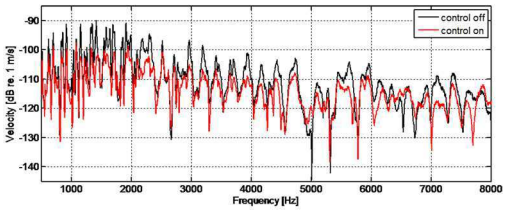
technology solution

THE TECHNOLOGY

Many piezoelectric control approaches rely on complex digital electronics to implement model-based feedback control algorithms in order to reduce structural vibrations. NASA's new device leverages a highly directional, diamond-shaped actuator with interdigitated electrodes and four miniature accelerometers at the corners to sense vibration. The diamond shape simplifies actuator coupling to the underlying structures, eliminating edge moments present in most piezoelectric actuators, and thereby enabling a matched actuator/sensor pair with the accelerometers as sensors. This matched pair greatly simplifies the control electronics; accelerometer responses are summed, integrated amplified, and then feed back to the actuator using analog electronics. The resulting control action is equivalent to active damping, resulting in lower structural vibration. The compact design of the actuator allows it to be mounted on a surface or incorporated within, and the overall size of the actuator can be optimized to target a range of problem frequencies.



Impulse response of a damped flexible structure can be evaluated by measuring velocity (rate of change in displacement for a single point on the structure). In this example, the structure receives an impulse at 0.25 seconds and experiences more vibration for a longer amount of time with control off (black lines) than with control on (red lines).



Velocity measurements at a single point on a Plexiglas panel with the control system powered off (black curve) and on (red curve). Peak reduction was 15 dB, and integrated reduction from 500 HZ to 8,000 HZ was almost 6 dB.

PUBLICATIONS

Patent No: 8,760,039

More Information

National Aeronautics and Space Administration

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